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Developing a fuzzy group AHP model for prioritizing the factors affecting success of High-Tech SME's in Iran: A case study

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Abstract

Small and medium enterprises (SME's) play a vital role in economic development of countries. It has been estimated that about 80 percent of world economic growth is created by SME's. This research aims to develop a model to evaluate factors affecting Iranian high-tech SME's success. For this purpose a hierarchal model with 10 main factor and 47 sub factors has been suggested. Since the evaluating factors were qualitative, a fuzzy modification of the group Analytic Hierarchy Process (AHP) method was applied and Chang’s extended analysis has been applied to analyze the fuzzy data. Finally, considering the relative importance of criteria, Critical Success Factors (CSF's) of high-Tech SME's were identified. These CSF's were employed in a fuzzy TOPSIS model in order to performance evaluation and rank the 17 high-tech firms located in Bio-Technology Incubator of Karaj. Results show that entrepreneur related factors, market characteristics and Product features are the most important success factors of Iranian high-tech SME's respectively.

Keywords: High-Tech Small and medium enterprises (SME's), Critical Success Factors (CSF's), fuzzy Multi-Criteria Decision Making (MADM) methods, Analytic Network Process (ANP), Fuzzy TOPSIS;

1. Introduction

Whilst the dependence of modern economies development on new business is widely acknowledged, the role of new exporting high-tech business in Iran is seen as vital. Since high-tech SMEs, create and implement technological innovations, they playing an important role in economic development by increasing living standards, employment, productivity and competitiveness (Commission, 2002)

Establishing a successful small or medium-sized enterprise (SME) is very difficult in any sector of industry. Thought establish a technology-based SME, is even more challenging and complex (Litvak, 1993). Because of the risk involved in innovation activities, the variation in performance among high-tech SMEs is remarkable and only a very small fraction of these firms grow rapidly (Commission, 2002).

High-technology industries are mainly characterized by growing turbulence, and time- and information-Intensive environments (Mohr, Sengupta, & Slater, 2009). A model which determines the relative importance of factors affecting high-tech SME's success should be valuable.

Obviously, it is a significant concern for the managers of such companies, to find means to survive and succeed in such a turbulent and competitive environment. Also because of the role these companies play in achieving an

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innovative and progressive economy, Success of these is very important for governments too (Warren & Hutchinson, 2000).

Although defining high-tech SMEs has beenthe subject of debate, and there is not a broadly accepted definition for these enterprises (Oakey, Rothwell, Cooper, & Oakey, 1988). a broad definitionis the businesses whose activities have a great dependence on innovation in science and technology (Medcof, 1999). The min characteristics of high-tech SME's include; heavier investment in R&D activities than the national average; employing a higher percentage of engineers and scientists than industry average; producing innovative and technologically advanced products; are dynamic in nature and have short product development cycles (Reeble, 1990)(Covin & Slevin, 1991)(Chorev & Anderson, 2006).

The purpose of this article is to review the literature on success factors for high-tech SME's and to prioritize these factors. Based on this fact that the factors affecting high-tech SME's success should be measured not separately, in this study we make use of Multi-attribute decision making (MADM) approach, which allows multi-criteria and simultaneous evaluation.

2.Literature review:

From 1990s, a large amount of research has been conducted in an attempt to identify factors contributing to SMEs success. Thought, to the best of our knowledge, no such researches about identifying or prioritizing these factors has been carried out in Iran to date.

In the following, with special focus on high-tech SME's a number of most important studies dealing with SME's performance and success are summarized.

Table 1 Literature review on factors affecting SME's success

Author	Description
Oakey (1995)	Investigation on barriers to new high-tech firms growth
Ackroyd (1995)	Determining the characteristics of successful small UK based IT firms
Oakey and Mukhtar (1999)	Reviewing the literature of high-tech SME's
Man, Lau and Chan (2002)	Reviewing the literature of SME's success factors
Kakati (2003)	Determining the Success criteria in high-tech new ventures.
Rogoff, Lee and Suh (2004)	Attributions by entrepreneurs and experts of the factors that cause small business success
Chorev and Anderson (2006)	Critical success factors of Israeli high-tech start-ups
Benzing, Chu, and Kara (2009)	Investigation on motivations, success factors, and problemsof entrepreneurship in Turkey
Karpak and Topcu (2010)	Prioritizing the factors affecting Turkish small medium manufacturing enterprises success
Chittithaworn, et al (2011)	Investigation on factors affecting business success SMEs in Thailand

3. Methodology

Many conflicting qualitative and quantitative criteria play role in success of high-tech SME's. Qualitative criteria are often accompanied by ambiguities and vagueness. To cope with this problem, an integration of Analytic Hierarchy Process (AHP) and fuzzy set theory suggested in this study. The crisp pairwise comparison in the conventional AHP seems to be insufficient and imprecise to capture the right judgments of decision-maker(s). Therefore, in this study, a fuzzy logic is introduced in the pairwise comparison of AHP to make up for this deficiency in the conventional AHP, called as fuzzy AHP.Chang (1992, 1996) extent analysis method has been applied for fuzzy AHP. Also in this study considering the calculated weights of criteria, high-tech SME's critical success factors (CSF's) will be determined. This CSF's will be used in a fuzzy TOPSIS model in order to performance evaluation and rank the 17 high-tech firms located in Bio-Technology Incubator of Karaj.The theoretical levels of the fuzzy TOPSIS method used in this study can be found in (Chen, 2000).

Here, we are not going to explain all the intricacies and details of the methodology due to space limitations. Below we give enough of the general approach to enable the reader to follow the paper with ease.

4. Application

The purpose of this study is to determining the relative importance of factors contributing to high-tech SMEs success and to rank 17 high-tech firms located in bio incubator of Karaj based on the results of previous step. We are not going to explain all the intricacies and details of the methodology due to space limitations. Below we give enough of the general approach to enable the reader to follow the paper with ease. Proposed model to achieve mentioned targets is composed of the following steps (See **Error! Reference source not found.**):

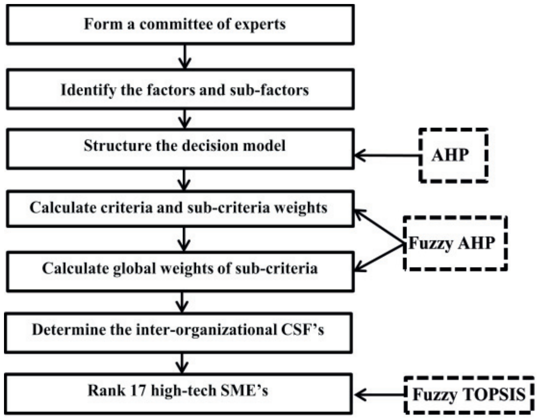

Figure 1Schematic framework of the proposed model

Step 1: Form a committee of experts: For the application, an expert team with 6 members was formed. These experts were university professors and managers of high-tech firms.
Step 2: Identify the factors and sub-factors to be used in the model.In this study, reviewing the literature and interviewing with experts, 13 intra-organizational and 34 inter-organizational success factors identified to be effective in high-tech SME's success. Also These factors categorized into 10 main criteria (7 inter-organizational and 3 environmental criteria). These factors and sub factors is demonstrated in Table 4
Step 3: Structure the AHP model hierarchically based on the factors and sub-factors identified at Step 2.
Step 4: Determine the local weights of the factors and sub-factors by using pair wise comparison matrices. The fuzzy scale regarding relative importance to measure the relative weights is given in Table3. This scale is proposed by Kahraman et al. (2006).

Table 2 The linguistic scale for relative dominance and their corresponding triangular fuzzy numbers (Kahraman, 2008).

Linguistic scale [a]	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Just equal	(1,1,1)	(1,1,1)
Equal dominance	(1/2,1,3/2)	(2/3,1,2)
Weak Dominance	(1,3/2,2)	(1/2,2/3,1)
Strong dominance	(3/2,2,2.5)	(2/5,1/2,2/3)
Very strong dominance	(2,2.5,3)	(1/3,2/5,1/2)
Absolute dominance	(2.5,3,7/2)	(2/7,1/3,2/5)

[a] For pairwise verbal comparisons, dominance of element i over element j may be interpreted as importance, preference or influence

Step 5: Calculate the global weights for the sub-factors. Global sub-factor weights are computed by multiplying local weight of the sub-factor with the local weight of the factor to which it belongs.
Step 6: determine the inter-organizational CSF's. Based on the weights calculated in previous step, the 10 inter-organizational sub-factors with higher weights is determined as CSF's. These sub-factors and their normalized weights are demonstrated in Table 5.

Step 7: Rank 17 high-tech firms. This step required the criteria weight information to calculate the weighted normalized rating. The weights of CSF's calculated former with fuzzy AHP. Based on the weights of CSF's, performance of 17 high-tech firms located in bio incubator of Karaj is evaluated in this step. Fuzzy TOPSIS is employed in order to assess these firms. 3 experts and managers of bio incubator answered the questionnaires in this step. The results of analyzing decision matrix including distance of each alternative from fuzzy positive ideal reference(d_i^*), distance of each alternative from fuzzy negative ideal reference (d_i^-), closeness coefficient (CC_i) and final ranking of the firms are summarized in Table 6.

For ranking alternatives using CC_i index, we can rank alternatives in decreasing order. The alternative with the highest CC_i value will be the best choice.

Finally, ranking the alternatives according to Table 6 is as follows:

A10 >A11>A13 >A8 >A2 >A14 >A5 >A4>A17 >A1>A15>A7 >A12 > A16 >A3>A6>A9

Table 3 Fuzzy AHP analysis results

Main criteria	Factors	Local Weight	Global Weight	Main criteria	Factors	Local Weight	Global Weight
Human resource (0.115)	Expertise and competence	0.32	0.037	Product characteristics (0.116)	Product Price	0.166	0.019
	Experience	0.25	0.029		Product quality	0.199	0.023
	Education	0.17	0.02		Uniqueness of product	0.189	0.022
	Teamwork skills	0.25	0.029		After sales service	0.161	0.019
Strategic (0.111)	Strategic planning	0.35	0.039		Easiness of use	0.127	0.015
	Flexibility	0.31	0.034		Product Life cycle	0.158	0.018
	Reengineering	0.22	0.024	Firm expertise (0.078)	Marketing	0.22	0.017
	Strategic Alliance	0.13	0.014		Human resource management	0.14	0.011
Entrepreneurs characteristics (0.112)	experience	0.195	0.022		Finance & accounting	0.15	0.012
	Risk Taking	0.147	0.017		R$D	0.26	0.021
	Creativity and innovation	0.147	0.017		Customer Service	0.22	0.018
	Leadership skills	0.196	0.022	policies and regulations (0.082)	Relationship with global market	0.08	0.007
	Managerial style	0.196	0.022		Government support (the support of domestic products)	0.25	0.021
	Family support	0.12	0.013		Copyright and Intellectual Property Rights	0.25	0.021
Organizational (0.081)	Organizational structure	0.13	0.011		SMEs protection laws	0.24	0.02
	Organizational culture	0.17	0.014		Labor laws	0.17	0.014
	Firm Life Cycle	0.21	0.017	Market characteristics (0.099)	Demand	0.30	0.03
	Being a learning organization	0.22	0.018		Intensity of competition in the industry	0.28	0.028
	size	0.09	0.007		Degree of uncertainty in the industry	0.20	0.02
	up-to-dateness	0.19	0.015		Access to suppliers	0.14	0.013
Financial (0.110)	The initial Investment	0.37	0.04		Access to distribution channels	0.08	0.007
	Liquidity	0.31	0.034	Technological (0.093)	Access to skilled workforce	0.40	0.037
	Firms access to financia resources	0.33	0.036		Ability to import equipment	0.30	0.028
					relation between industry and university	0.30	0.028

Table 4 CSF's and their normalized weights

Critical Success Factor	The initial Investment	Strategic planning	Expertise and competence	access to financial resources	Organizational Flexibility	Liquidity	Human Resource Experience	Teamwork skills	Reengineering	Product quality
Normalized weight	0.123	0.12	0.114	0.111	0.105	0.105	0.089	0.089	0.074	0.071

Table 5 TOPSIS analysis results.

Firm	d_i^*	d_i^-	CC_i	Rank	Firm	d_i^*	d_i^-	CC_i	Rank
A1	0.506	0.6396	0.5583	10	A9	0.6137	0.5177	0.4576	17
A2	0.4416	0.6389	0.5913	5	A10	0.3781	0.6809	0.643	1
A3	0.5194	0.6134	0.5415	15	A11	0.3988	0.7041	0.6384	2
A4	0.4669	0.6286	0.5738	8	A12	0.5123	0.6104	0.5437	13
A5	0.4779	0.6626	0.5809	7	A13	0.4463	0.6678	0.5994	3
A6	0.5439	0.5711	0.5122	16	A14	0.4439	0.6412	0.5909	6
A7	0.5043	0.6165	0.5501	12	A15	0.5079	0.6274	0.5526	11
A8	0.4557	0.6683	0.5946	4	A16	0.5283	0.6248	0.5419	14
					A17	0.5124	0.6595	0.5627	9

Conclusion

The objective of the research was to develop a hybrid multi criteria technique to evaluate high-tech SME's performance based on critical success factors. This research conducted as two main stages. At the first stage a hierarchal model with 3 levels proposed to priorities the factors affecting success of high-tech SME's in Iran.
At the second stage, using the CSF's and their relative weights, fuzzy TOPSIS method is used for evaluating the performance of 17 high-tech SME's located in Bio-Technology Incubator of Karaj and determining the ranking of them.
With the factor weights found by using fuzzy AHP, it can be determined which factors has more effect on SME's success. The first three important main factors in SME's success are Product characteristics, Human resource and Entrepreneurs characteristics. The results of this study also suggest that initial Investment, Strategic planning and Access to skilled workforce are the most important sub-factors for high-tech SME's success.
The proposed methodology requires expert judgments. Experts were interviewed individually without interacting and not knowing each other's judgments. Also, the uncertainty of human decision-making is taken into account through the fuzzy logic.
Results of this paper can provide guidelines to develop small-medium enterprises in Iran and other countries with similar economic infrastructure and cultural influences.

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